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14. ABSTRACT

This was a two part performance proposal consisting of 1. Completion of a computer simulation code to model the Earth's magnetosphere and ionosphere coupling in a realistic magnetic field; 2. development of a new plasma kinetic theory, the guiding field line approximation, and application of it to the calculation of plasma current in a steady state. We started with the ionospheric electrodynamics for a realistic magnetic field to solve Vasyliunas' coupling equation which represents the coupling of the Earth's magnetosphere and ionosphere. Model was constructed on the basis of International Geomagnectic Reference Field, we assumed that no electirc potentia drop along filed lines and no magnetospheric current exist except for a birkeland current that flows along a fux tube from one hemisphere to another.

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FINAL REPORT OF THE PROPOSAL "COUPLING OF EARTH'S MAGNETOSPHERE AND IONOSPHERE IN A REALISTIC MAGNETIC FIELD" (January 1, 1996 — May 31, 2000)

GRANT NUMBER: F49620-96-1-0236
PRINCIPAL INVESTIGATOR: Tian-Sen Huang
INSTITUTION: Prairie View A&M University

1. Summary of the research performance:

The research performance of this proposal consists of two parts: (1) Completion of a computer simulation code to model the Earth's magnetosphere and ionosphere coupling in a realistic magnetic field; (2) development of a new plasma kinetic theory, the guiding field line approximation, and application of it to the calculation of plasma current in a steady state. The work was conducted mainly by the Principal Investigator of this proposal, Tian-Sen Huang, his associate Philippe Le Sager, and his student Shan Gao with participation of other research staff and students.

In the first part of the performance, we started with the ionospheric electrodynamics for a realistic magnetic field to solve *Vasyliunas'* coupling equation which represents the coupling of the Earth's magnetosphere and ionosphere. For a preliminary magnetosphere-ionosphere coupling model constructed on the basis of International Geomagnetic Reference Field (IGRF), we assumed that no electric potential drop along field lines and no magnetospheric current exist except for a Birkeland current that flows along a flux tube from one hemisphere to other one and ionospheric Pederson and Hall conductances are constant. For the magnetic field we took the Euler potentials (α, β) as the coordinates. Spent several years, a code of the ionosphere-magnetosphere coupling in IGRF is completed. The code has been tested carefully, and been used to investigate the effects of higher magnetic moments (quadrupole, octupole, etc.) on the ionospheric current and Birkeland current driven by a neutral wind rotating with a constant angular velocity that is parallel to that of the solid Earth. IN addition, the code with some modification applied to study the ionospheric dynamo effects, and the magnetic field perturbation caused by the ionospheric current and Birkeland current on the Earth's surface. This code is one of a few similar code in the US, and the only one that uses the Euler potentials as the magnetic field coordinates. Some results have been reported in AGU (American Geophysical Union)

1997 Fall Meeting, AGU 1998 Fall Meeting, AGU 1999 Spring Meeting, and Air Force P. I. Meeting. The work on the calculation of the magnetic field perturbation with the ionosphere-magnetosphere coupling code will be given in the coming AGU 2000 Fall Meeting.

A piece of work to incorporate Prairie View magnetosphere-ionosphere coupling code into a more sophisticated and more practical space plasma code, the Rice Convection Model, is in progress.

The second part of our performance is a development in space plasma theory by introducing a new physics quantity of wobble magnetic moment and forming a new model for charged particle motion and plasma behave, the guiding field line approximation. It is a significant contribution to the space plasma theory after the guiding center model. This approximation has been used to calculate the Birkeland current in the magnetospheric plasma and shown great advantage in comparison with other theories including MHD theory and drift kinetic theory. Some results have been reported in AGU 1999 Spring Meeting and Air Force P. I. 1999 Meeting, and published in Journal of Geophysical Research.

The new theoretical model is not limited to the application for space plasma physics, but also applicable for fusion plasma physics. A paper on the calculation of tokamak plasma currents has been published in Physics of Plasma.

2. Performance in education

There are two undergraduate students and one graduate student who participated in the proposed work. Through the participation in this project, the undergraduate students learned basic knowledge on space plasma physics and basic skills in running computer simulation code. The graduate students finished his master degree with the work on this project.

3. Research Capability Improvement

During the performance of this proposal, we added several computer work station and set up a computer work station cluster. The computer system were equipped with many packages of scientific software such as IDL, IMSL and Matlab. In addition, several computers were improved by adding more ram and hard disk memories.

4. Publications and reports

T. S. Huang al., Coupling between ionosphere and magnetosphere in a realistic magnetic field: Distribution of electric field driven by a rotating neutral wind in ionosphere, AGU 1997 Fall Meeting.

P. Le Sager and T. S. Huang, Ionospheric current driven by a neutral wind: comparison between the tilted dipole and the realistic magnetic field, AGU 1998 Fall Meeting.

T. S. Huang, Birkeland current in a convecting plasma in a 2D dipole field: An application of the guiding field line model, AGU 1999 Spring Meeting.

P. Le Sager and T. S. Huang, Ionospheric current driven by a stripe neutral wind: A comparison between the tilted dipole and the realistic magnetic field, AGU 1999 Spring Meeting.

T. S. Huang, Coupling the magnetosphere and ionosphere in a realistic magnetic field, AFOSR Space Sciences Spring 1999 Review.

T. S. Huang, Wobble motion of a particle's guiding center and the related magnetic moment, Journal of Geophysical Research, Vol. 105, 5541, 2000.

Yu. Petrov and T. S. Huang, Plasma current in tokamak conditions: An application of the guiding field line model, Physics of Plasmas, Vol. 7, 4095, 2000.

P. Le Sager and T. S. Huang, Ground magnetic perturbations due to ionospheric dynamo: Important of the Earth non-magnetic distortions, AGU 2000 Fall Meeting.